July 31, 2019 Project No. 19127365

Philip Thibert, Project Manager - Land Development & Infrastructure
Brigil
98 Lois Street
Gatineau, QC
J8Y 3R7

HYDROGEOLOGICAL ASSESSMENT
PREDICTED GROUNDWATER INFLOW AND RADIUS OF INFLUENCE
99 PARKDALE AVENUE
OTTAWA, ONTARIO

Dear Mr. Thibert:

This letter presents the results of a hydrogeological assessment carried out by Golder Associates Ltd. (Golder) to estimate the volume of groundwater and radius of influence associated with dewatering the excavation required for the proposed high-rise development at 99 Parkdale Avenue in Ottawa, Ontario.

Hydraulic Testing

Hydrogeological tests were completed on two on-site boreholes to estimate the hydraulic conductivity (K) of the bedrock below the site. Constant head packer testing was completed in both open boreholes within seven, approximately four metre length, overlapping intervals per borehole. Results from the packer testing were analyzed using the Houlsby (1976) method (refer to Attachment A). In both boreholes, only the results obtained in the uppermost interval could be interpreted. The hydraulic conductivity in the lower six intervals were too low to measure using the available testing equipment. Hydraulic conductivity estimates for the uppermost interval in the two boreholes are presented in the following table:

	BH12-101	BH12-102
Top of Interval (mbgs)	1.7	2.7
Bottom of Interval (mbgs)	5.4	6.4
Estimated Hydraulic Conductivity (metres per second)	$4x10^{-6}$	$3x10^{-6}$

Note: mbgs – metres below ground surface

Following the packer testing, a monitoring well was installed within each borehole, and slug tests were carried out using the two monitoring wells. Both falling and rising head tests were carried out on BH12-101 whereas, due to the slow recovery of the water level in the well, only a falling head test was carried out at BH12-102.

The results of the slug testing were analyzed using the Bouwer and Rice (1976) method (refer to Attachment A). Hydraulic conductivity estimates for the slug tests in the two boreholes are presented in the following table:

	BH12-101	BH12-102
Top of Interval (mbgs)	1.8	16.2
Bottom of Interval (mbgs)	5.5	19.8
Estimated Hydraulic Conductivity – Falling Head Test (metres per second)	$4x10^{-6}$	$3x10^{-9}$
Estimated Hydraulic Conductivity – Rising Head Test (metres per second)	$9x10^{-6}$	--

Note: mbgs – metres below ground surface

The estimated K values for the upper portion of the bedrock ranged from $3x10^{-6}$ to $9x10^{-6}$ metres per second (m/s) which is relatively consistent. The two methods for estimating K (packer testing and rising/falling head tests) demonstrate that the deeper bedrock formations were significantly less permeable than the upper more weathered bedrock.

Numerical and Analytical Modelling

Two separate models were used to predict the radius of influence from the excavation and the groundwater inflow to the excavation. A steady-state numerical model was developed to predict the long-term inflow and radius of influence, and an analytical model was used to predict initial flows into the excavation prior to reaching steady-state conditions (i.e., during initial construction).

Numerical Modelling

Work within the excavation and the final design of the building would require control of groundwater levels. An un-calibrated simplified three-dimensional numerical model (MODFLOW) was constructed to simulate steady-state dewatering and drawdown at the site. The model was developed using information from the two existing boreholes completed at the site (refer to Attachment B for borehole logs).

The numerical model covers an area of approximately 1,000 metres by 1,000 metres divided into 2.5 metre by 2.5 metre grid blocks in the area of the excavation and increasing in size towards the edge of the model domain. There are 12 layers in the model with a uniform thickness of 5 metres. The bedrock surface was assumed to be a constant 59 metres above sea level (asl) across the entire model domain based on surveyed ground surface elevations and the borehole logs.

Boundary conditions were established in the model using constant heads. To represent the Ottawa River, located approximately 300 metres north of the site, a uniform constant head boundary condition equivalent to 54 metres asl was placed on the northern edge (all layers) of the model. A uniform constant head boundary of 58 metres asl was placed on the southern edge (all layers), thus inducing groundwater flow towards the Ottawa River. All other boundaries in the model were no flow boundaries and no recharge was applied to the model domain.

Based on the information in the borehole logs and results from the hydrogeological testing, a simplified hydrostratigraphic model was developed for the bedrock in the area. It was assumed that there was a 5 metre thick weathered bedrock zone with a uniform isotropic K value of $4x10^{-6}$ m/s overlying more competent bedrock with a uniform isotropic K value of $3x10^{-9}$ m/s. It was assumed that the conditions encountered in the two boreholes at the site are similar to those throughout the modelled domain.

With this assumption of an "equivalent porous media", the rate of groundwater flow towards the excavation occurs as a function of the hydraulic gradient, the hydraulic conductivity, and storage properties of the surrounding modelled hydrostratigraphy. While groundwater flow in bedrock aquifers is controlled primarily by fractures, an equivalent porous media approach was used in the simplified numerical model to represent the overall groundwater flow conditions. This is considered reasonable provided the scale of the observation (i.e., in this case the extent of dewatered area) is much greater than the scale of the individual fractures.

The excavation was simulated in the numerical model using drain boundary conditions and inactivating the cells within the excavation. A 30 metre by 60 metre excavation was introduced into the numerical model by inactivating the cells within the excavation to the simulated depth of the excavation. For this assessment, the bottom of the excavation was simulated at elevation 38 metres asl (approximately 22 metres below the ground surface).
A drain boundary condition was applied to all cells surrounding the excavation in order to simulate dewatering in the excavation. The drain boundary condition of the cells below the excavation was set at 38 metres asl (bottom of the excavation) and those on the side of the excavation were set to the bottom of the cell plus 10 percent of the thickness of the cell.

For this assessment, the hydraulic head at the excavation site under initial conditions (pre-excavation) was set at approximately 58 metres asl (as measured in July 2012 in the open boreholes prior to packer testing). The drawdown associated with the dewatering was calculated as the difference between the steady-state solution of the initial modelled heads (without the excavation) and the steady-state solution of final modelled heads (within the excavation).

Relative to the modelled groundwater levels, the simplified numerical model predicts approximately 1 metre of drawdown at about 150 metres from the excavation, and the predicted steady-state flow rate into the excavation was estimated to be about 3,000 Litres per day (L/day).

Analytical Modelling

The Dupuit-Forchheimer analytical solution was used to estimate the initial groundwater inflow into the excavation during construction (refer to Attachment C). The analytical solution was run twice using the same bedrock hydraulic conductivities used in the numerical model ($4x10^{-6}$ m/s weathered bedrock and $3x10^{-9}$ m/s underlying competent bedrock). For the weathered bedrock, it was assumed that the drawdown would be across the full five-metre thickness. The initial groundwater flow into the excavation from the weathered bedrock was estimated to be approximately 230,000 L/day. Predicted inflow through the competent bedrock (assuming a 22 metre deep excavation) is significantly less than that predicted for the weathered zone (approximately 4,000 L/day).

Modelling Summary

The results of the hydrogeological modelling indicate that groundwater inflow into the excavation will decrease over time as the bedrock dewaters within the zone of influence. The initial groundwater inflows are estimated to be approximately 230,000 L/day and are predicted to decrease to approximately 3,000 L/day as the construction dewatering progresses towards steady-state. The vast majority of the flow into the excavation will be from the weathered bedrock near the surface of the site. During the progression to steady-state and once steady-state is reached, short-term increases in groundwater inflows would be expected following precipitation events where the weathered zone is recharged and subsequently drains into the excavation.

The predicted steady-state radius of influence for construction and post-construction is approximately 150 metres, and the long-term (post-construction) groundwater inflow is predicted to be approximately 3,000 L/day (assuming the weathered zone remains dewatered).

During the construction period, precipitation accumulation for the proposed excavation area would be approximately 126,000 L/day during a 70 millimetre precipitation event (return rate of 10 years, as observed at the Ottawa International Airport).

Increases in post-construction flows would be expected following precipitation events where the weathered zone is recharged and subsequently drains into the post-construction sump.

Permit to Take Water/Environmental Activity and Sector Registry

According to O.Reg. 63/16 and O.Reg 387/04, if the volume of water to be pumped from an excavation for the purpose of construction dewatering is greater than 50,000 litres per day and less than 400,000 litres per day, the water taking will need to be registered as a prescribed activity in the Environmental Activity and Sector Registry (EASR) and requires the completion of a "Water Taking Plan". Alternatively, a Permit to Take Water (PTTW) is required from the Ministry of the Environment, Conservation and Parks (MECP) if a volume of water greater than 400,000 litres per day is to be pumped from the excavations. Based on the groundwater conditions observed at the site, water taking exceeding 50,000, but less than 400,000 litres per day may be required to dewater groundwater and incident precipitation from the excavation. As a result, EASR registration may be necessary for the water taking associated with the proposed work.

Closure

We trust this hydrogeological assessment and supporting material is satisfactory. Should you require any clarification or additional materials, please do not hesitate to contact the undersigned.

Yours truly,

Golder Associates Ltd.

Brian Henderson, M.A.Sc., P.Eng.
Environmental Engineer

Jaime Oxtobee, M.Sc., P.Geo.
Senior Hydrogeologist/Associate

LICENSED PROFESSIONAL ENGINEER
B.J. HENDERSON
100110984
7/31/2019
PROVINCE OF ONTARIO

BH/JPAO/ca

https://golderassociates.sharepoint.com/sites/112765/project files/6 deliverables/hydrogeology/19127365-001-l-reva_hydrogeology_31july2019.docx

Attachments: Attachment A – Results of Hydrogeological Testing
Attachment B – Record of Borehole Logs
Attachment C – Predicted Radius of Influence and Estimated Inflow

APPENDIX A

Results of Hydrogeological Testing

Borehole 12-101 Test 7

Interval Information

Borehole Radius [R] (m)	Interval Information		
	Top (m)	Bottom (m)	Length (m)
0.038	1.65	5.41	3.76

Test Information

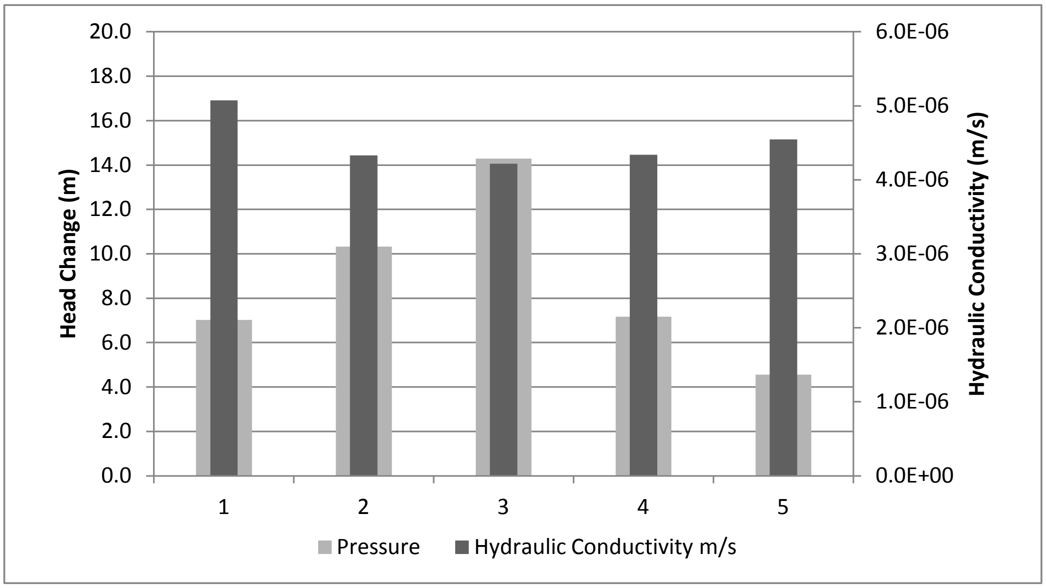
	Test Data		
1	Flow Rate (Q) = Pressure (P) =	1.8E-04 7.0	m^3/sec mH2O
2	Flow Rate (Q) = Pressure (P) =	2.3E-04 10.3	m^3/sec mH2O
3	Flow Rate (Q) = Pressure (P) =	3.1E-04 14.3	m^3/sec mH2O
4	Flow Rate (Q) = Pressure (P) =	1.6E-04 7.2	m^3/sec mH2O
5	Flow Rate (Q) = Pressure (P) =	1.1E-04 4.6	m^3/sec mH2O

Steady State Equation:
K=[Q*ln(L/D)+sqrt(1+(L/D)^2)]/[2(PI)LP]
(Thiem 1906)

Steps	Hydraulic Conductivity m/s
1	5.E-06
2	4E-06
3	4E-06
4	4E-06
5	5E-06

Comments:
Turbulent Flow
Report value for highest pressure

Pressure and Hydraulic Conductivity



Golder Associates

Constant Head Test

99 Parkdale Avenue

Ottawa, Ontario

BH12-101

Project No.	11-1121-0275
Date:	7/19/2012
Calcs By:	BH
Review:	DH

Borehole 12-102 Test 7

Interval Information

Borehole Radius [R] (m)	Interval Information		
	Top (m)	Bottom (m)	Length (m)
0.038	2.66	6.44	3.78

Steady State Equation:
K=[Q*ln(L/D)+sqrt(1+(L/D)^2)]/[2(PI)LP]
(Thiem 1906)

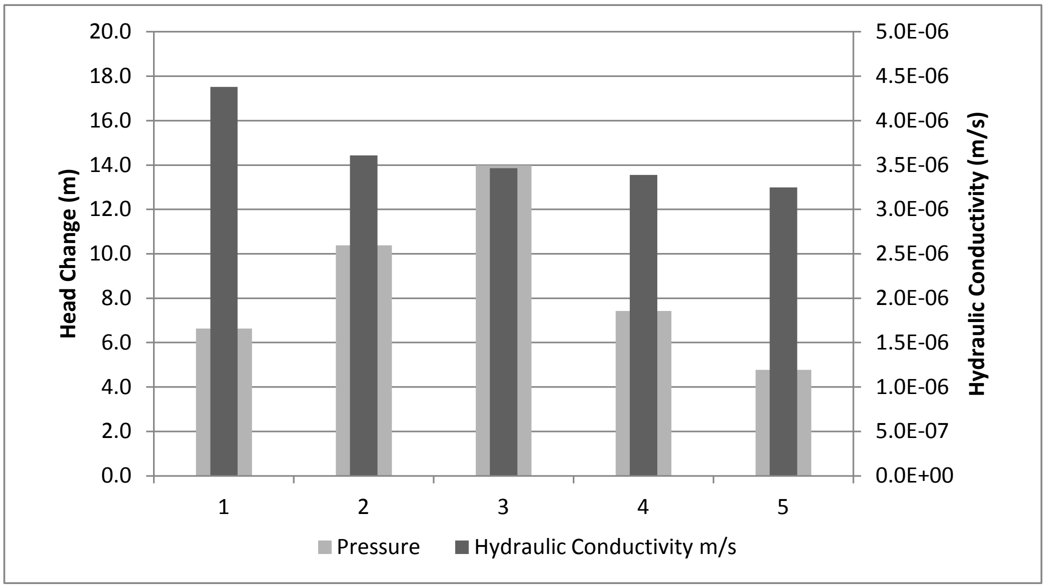
Steps	Hydraulic Conductivity m/s
1	4.E-06
2	4E-06
3	3E-06
4	3E-06
5	3E-06

Comments:
Filling or swelling
Report final value

Test Information

	Test Data		
1	Flow Rate (Q) =	1.5E-04	m^3/sec
	Pressure (P) =	6.6	mH2O
2	Flow Rate (Q) =	1.9E-04	m^3/sec
	Pressure (P) =	10.4	mH2O
3	Flow Rate (Q) =	2.5E-04	m^3/sec
	Pressure (P) =	14.0	mH2O
4	Flow Rate (Q) =	1.3E-04	m^3/sec
	Pressure (P) =	7.4	mH2O
5	Flow Rate (Q) =	8.0E-05	m^3/sec
	Pressure (P) =	4.8	mH2O

Pressure and Hydraulic Conductivity



	Constant Head Test **99 Parkdale Avenue** **Ottawa, Ontario**	**BH12-102**	
Golder Associates		Project No.	11-1121-0275
		Date:	7/19/2012
		Calcs By:	BH
		Review:	DH

BOUWER AND RICE SLUG TEST ANALYSIS
FALLING HEAD TEST BH12-101 (Shallow Rock)

$$K = \frac{r_c^{2} \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

where:

r_c = casing radius (metres);

R_e = effective radius (metres);

L_e = length of screened interval (metres);

r_w = radial distance to undisturbed aquifer (metres)

y_0 = initial drawdown (metres)

y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c = 0.02

r_w = 0.04

L_e = 3.66

$\ln(R_e/r_w)$ 3.15

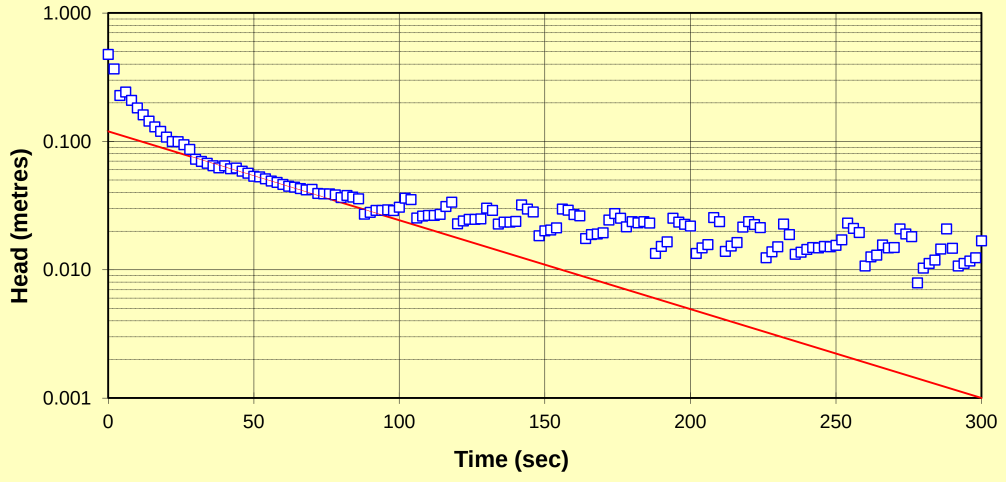
y_0 = 0.12

y_t = 0.00

t = 300.0

RESULTS

K=	4E-06	**m/sec**
	4E-04	**cm/sec**



Project Name: Urbandale 99 Parkdale
Project No.: 11-1121-0275
Test Date: 07/27/12

Analysis By: CHM
Checked By: BH
Analysis Date: 7/31/2012

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST BH12-101 (Shallow Rock)

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where K=m/sec

where:

r_c = casing radius (metres);

R_e = effective radius (metres);

L_e = length of screened interval (metres);

r_w = radial distance to undisturbed aquifer (metres)

y_0 = initial drawdown (metres)

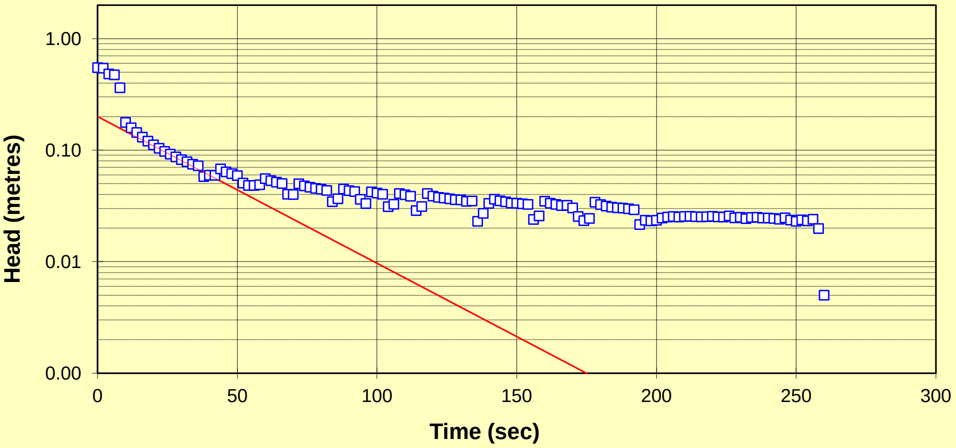
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.04
L_e =	3.35
$\ln(R_e/r_w)$	3.12
y_0 =	0.20
y_t =	0.00
t =	175.0

RESULTS

K=	9E-06	m/sec
	9E-04	cm/sec



Project Name: Urbandale 99 Parkdale
Project No.: 11-1121-0275
Test Date: 07/27/12

Analysis By: CHM
Checked By: BH
Analysis Date: 7/31/2012

BOUWER AND RICE SLUG TEST ANALYSIS
FALLING HEAD TEST BH12-102 (Rock)

$$K = \frac{r_c^{\,2} \ln\left(\frac{R_e}{r_w}\right)}{2L_e}\,\frac{1}{t}\,\ln\frac{y_0}{y_t}$$

where K=m/sec

where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);

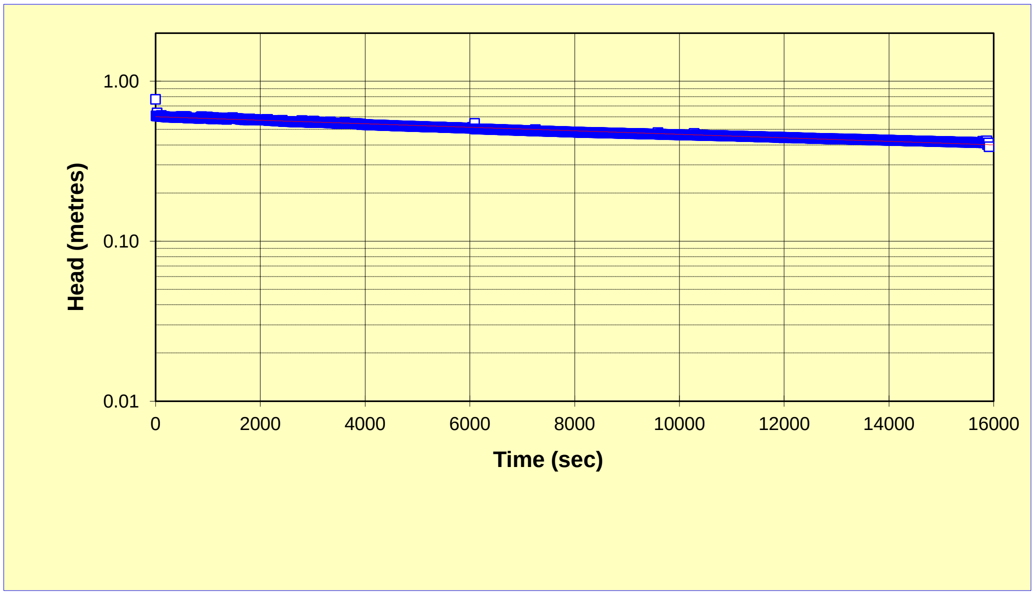
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c = **0.02**
r_w = **0.04**
L_e = **3.66**
$\ln(R_e/r_w)$ **3.87**
y_0 = **0.60**
y_t = **0.40**
t = **16000.0**

RESULTS

K= 3E-09 **m/sec**
3E-07 **cm/sec**



Project Name: Urbandale 99 Parkdale
Project No.: 11-1121-0275
Test Date: 07/27/12

Analysis By: CHM
Checked By: BH
Analysis Date: 7/31/2012

APPENDIX B

Record of Borehole Logs

PROJECT: 11-1121-0275-2000

RECORD OF BOREHOLE: 12-101

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: July 16, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	59.90				
0	Power Auger 200 mm (HS)	Intermixed dark brown silty sand, brick, and gravel (FILL)	0.00				Bentonite Seal
1		Compact to dense SILTY SAND, trace gravel (GLACIAL TILL)	59.14 0.76	1	SS	40	
	Rotary Drill NQ Core	Slightly weathered to fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	0.91	C1	NQ RC	DD	Pentlandite Seal
2							Silica Sand
3		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	57.41 2.49	C2	NQ RC	DD	
4				C3	NQ RC	DD	32 mm Diam. PVC #10 Slot Screen
6				C4	NQ RC	DD	
8				C5	NQ RC	DD	
9		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone and very small white calcite inclusions	51.16 8.74	C6	NQ RC	DD	
10							Bentonite Seal
11				C7	NQ RC	DD	
12		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	48.09 11.81	C8	NQ RC	DD	
14				C9	NQ RC	DD	
15				C10		DD	

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DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF BOREHOLE: 12-101

SHEET 2 OF 2

LOCATION: See Site Plan

BORING DATE: July 16, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
15	Rotary Drill NQ Core	Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone			C10	NQ RC	DD				
16				43.49 16.41							
17		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone -Slickensided sheer zone between 17.40 and 17.47 m depth			C11	NQ RC	DD				
18					C12	NQ RC	DD				
19											
20					C13	NQ RC	DD				Bentonite Seal
21											
22					C14	NQ RC	DD			UCS = 199 MPa	
23					C15	NQ RC	DD				
24					C16	NQ RC	DD				
25				34.55 25.35							
		End of Borehole									
26											W.L. in Screen at Elev. 57.76 m on July 27, 2012
27											
28											
29											
30											

MIS-BHS 001 1111210275.GPJ GAL-MIS.GDT 08/17/12 P.L.G.

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF DRILLHOLE: 12-101

SHEET 1 OF 2

LOCATION: See Site Plan

DRILLING DATE: July 16, 2012

DATUM: Geodetic

DRILL RIG: CME 850

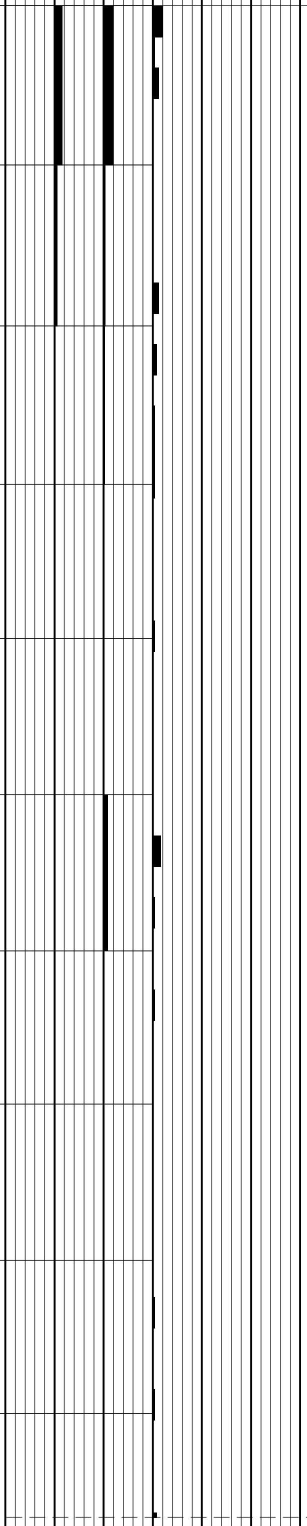
INCLINATION: -90° AZIMUTH: ---

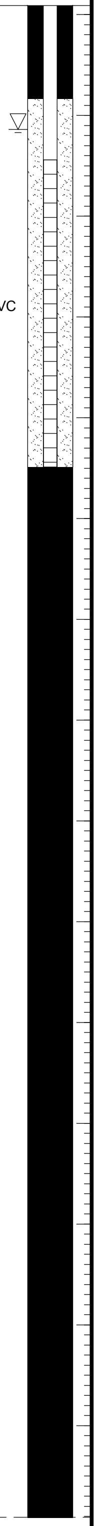
DRILLING CONTRACTOR: Marathon Drilling

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	
		BEDROCK SURFACE	58.99		
1	Rotary Drill NQ Core	Slightly weathered to fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	0.91	1	Pentlandite Seal
2			57.41		Silica Sand
		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	2.49	2	
4				3	32 mm Diam. PVC #10 Slot Screen
6				4	
8			51.16	5	
9		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone and very small white calcite inclusions	8.74	6	
11			48.09	7	Bentonite Seal
12		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	11.81	8	
14				9	
15				10	

Column headings: SYMBOLIC LOG; COLOUR % RETURN; FLUSH; RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20); R.Q.D. % (80 60 40 20); FRACT. INDEX PER 0.3 m (5 10 15 20); DISCONTINUITY DATA: B Angle (0 90 180 270), DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn; HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3}); Diametral Point Load Index (MPa) (2 4 6); RMC -Q' AVG.





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DEPTH SCALE

1 : 75

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF DRILLHOLE: 12-101

SHEET 2 OF 2

LOCATION: See Site Plan

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 16, 2012

DRILL RIG: CME 850

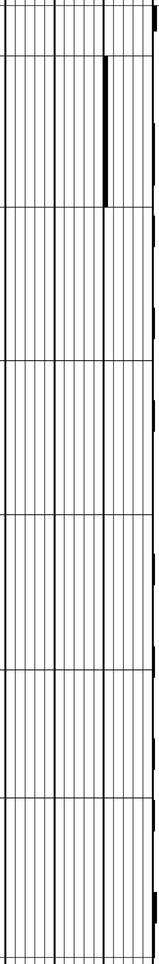
DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint	PL - Planar	PO- Polished
FLT - Fault	CU- Curved	K - Slickensided
SHR- Shear	UN- Undulating	SM- Smooth
VN - Vein	ST - Stepped	Ro - Rough
CJ - Conjugate	IR - Irregular	MB- Mechanical Break
BD- Bedding		BR - Broken Rock
FO- Foliation		
CO- Contact		
OR- Orthogonal		
CL - Cleavage		

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	
		--- CONTINUED FROM PREVIOUS PAGE ---																		
16	Rotary Drill NQ Core			43.49	10															
17		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone -Slickensided sheer zone between 17.40 and 17.47 m depth		16.41	11															
18					12															
19																				
20					13															
21					14															Bentonite Seal
22																				
23					15															
24					16															
25				34.55																
		End of Drillhole		25.35																
26																				W.L. in Screen at Elev. 57.76 m on July 27, 2012
27																				
28																				
29																				
30																				



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF BOREHOLE: 12-102

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: July 17, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	59.75				
0	Power Auger 200 mm (HS)	Intermixed dark brown silty sand, gravel, brick, and crushed stone (FILL)	0.00	1	SS	>50	
1	Rotary Drill NQ Core	Slightly weathered to fresh thinly bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	58.84 0.91	C1	NQ RC	DD	Bentonite Seal
3		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone	57.24 2.51	C2	NQ RC	DD	
5				C3	NQ RC	DD	
6				C4	NQ RC	DD	∇
8				C5	NQ RC	DD	Pentlandite Seal
9				C6	NQ RC	DD	
11				C7	NQ RC	DD	
12				C8	NQ RC	DD	
14				C9	NQ RC	DD	
15				C10	NQ RC	DD	

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MIS-BHS 001 1111210275.GPJ GAL-MIS.GDT 08/17/12 P.L.G.

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF BOREHOLE: 12-102

SHEET 2 OF 2

LOCATION: See Site Plan

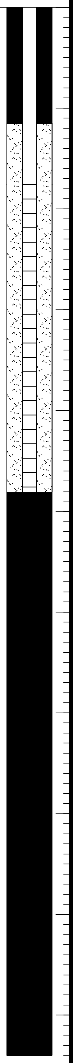
BORING DATE: July 17, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
15	Rotary Drill NQ Core	Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone			C10	NQ RC	DD				Pentlandite Seal
16											Silica Sand
17					C11	NQ RC	DD				
18					C12	NQ RC	DD				32 mm Diam. PVC #10 Slot Screen
19											
20					C13	NQ RC	DD				
21					C14	NQ RC	DD				
22											Pentlandite Seal
23					C15	NQ RC	DD				
24					C16	NQ RC	DD			UCS = 96 MPa	
25				34.35							
		End of Borehole		25.40							W.L. in Screen at Elev. 53.51 m on July 27, 2012
26											
27											
28											
29											
30											



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF DRILLHOLE: 12-102

SHEET 1 OF 2

LOCATION: See Site Plan

DRILLING DATE: July 17, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

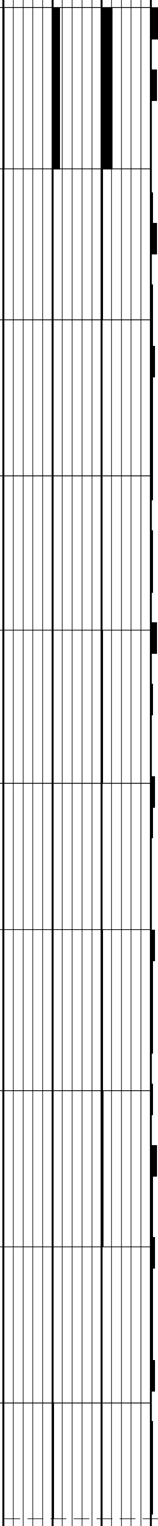
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

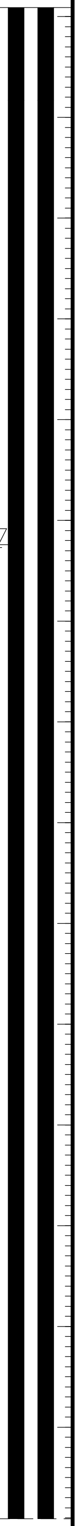
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	
		BEDROCK SURFACE		58.84																
1 2	Rotary Drill NQ Core	Slightly weathered to fresh thinly bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone		0.91 57.24	1															Bentonite Seal
3 4 5 6 7 8 9 10 11 12 13 14 15		Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone		2.51	2 3 4 5 6 7 8 9 10															▽ Pentlandite Seal





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DEPTH SCALE

1 : 75

Golder Associates

LOGGED: H.C.

CHECKED: T.M.S.

PROJECT: 11-1121-0275-2000

RECORD OF DRILLHOLE: 12-102

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: July 17, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

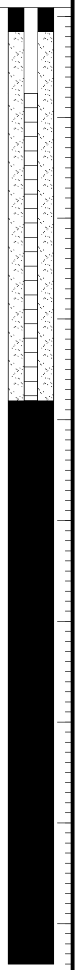
DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	
		--- CONTINUED FROM PREVIOUS PAGE ---																			
16	Rotary Drill NQ Core	Fresh thinly to medium bedded grey fine grained LIMESTONE BEDROCK, with very thin beds of dark grey dolomitic limestone			10																Pentlandite Seal
																					Silica Sand
17					11																
18																					32 mm Diam. PVC #10 Slot Screen
					12																
19																					
20					13																
21																					
					14																
22																					
																					Pentlandite Seal
23					15																
24																					
					16																
25				34.35																	
		End of Drillhole		25.40																	
26																					W.L. in Screen at Elev. 53.51 m on July 27, 2012
27																					
28																					
29																					
30																					



MIS-RCK 004 1111210275.GPJ GAL-MISS.GDT 08/17/12 P.L.G.

DEPTH SCALE
1 : 75

Golder Associates

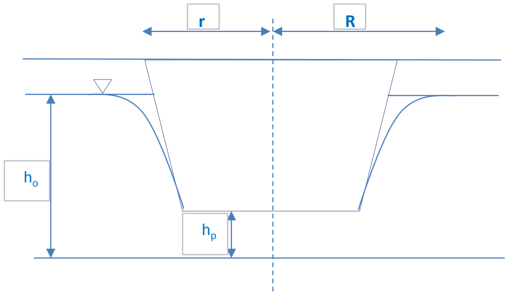
LOGGED: H.C.
CHECKED: T.M.S.

APPENDIX C

Predicted Radius of Influence and Estimated Inflow

Predicted Radius of Influence and Estimated Inflow

Dupuit-Forchheimer Equation: $Q=\pi K((h_o^2-h_p^2)/\ln(R/r))$



Weathered Bedrock

K (m/sec) 4.00E-06

h_o (m) 5.0

h_p (m) 0.0

r (m) 23.94

r - equivalent radius of pond

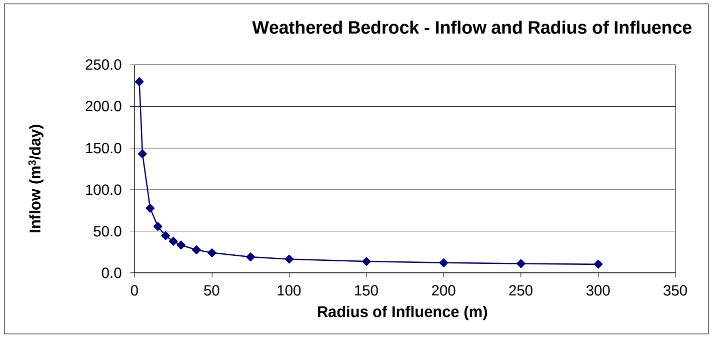
R - radius of influence

Equivalent radius of excavation

$AB=\pi r^2$

width of excavation A=	60	m
length of excavation B=	30	m
area=	1,800	m^2
r=	23.94	**m**

Q (m3/s)	R	Rad of Inf. from edge	m^3/day	L/day
2.7E-03	26.94	3	230	229,877
1.7E-03	28.94	5	143	143,086
9.0E-04	33.94	10	78	77,755
6.5E-04	38.94	15	56	55,790
5.2E-04	43.94	20	45	44,692
4.4E-04	48.94	25	38	37,956
3.9E-04	53.94	30	33	33,411
3.2E-04	63.94	40	28	27,627
2.8E-04	73.94	50	24	24,068
2.2E-04	98.94	75	19	19,128
1.9E-04	123.94	100	17	16,507
1.6E-04	173.94	150	14	13,686
1.4E-04	223.94	200	12	12,139
1.3E-04	273.94	250	11	11,136
1.2E-04	323.94	300	10	10,419



Competent Bedrock

K (m/sec) 3.00E-09

h_o (m) 32.0

h_p (m) 10.0

r (m) 23.94

r - equivalent radius of pond

R - radius of influence

Equivalent radius of excavation

$AB=\pi r^2$

width of excavation A=	60	m
length of excavation B=	30	m
area=	1,800	m^2
r=	23.94	**m**

Q (m3/s)	R	Rad of Inf. from edge	m^3/day	L/day
4.6E-05	28.94	5	4	3,966
2.5E-05	33.94	10	2	2,155
1.8E-05	38.94	15	2	1,546
1.4E-05	43.94	20	1	1,239
1.2E-05	48.94	25	1	1,052
1.1E-05	53.94	30	1	926
8.9E-06	63.94	40	1	766
7.7E-06	73.94	50	1	667
6.9E-06	83.94	60	1	600
6.4E-06	93.94	70	1	550
5.9E-06	103.94	80	1	512
5.6E-06	113.94	90	0	482
5.3E-06	123.94	100	0	458
4.8E-06	148.94	125	0	412
4.4E-06	173.94	150	0	379